Final Project Report to the NYSIPM Program,
Agricultural IPM 2002-2003

Project type: Research and Development; Continuing

Title: Developing Damage and Economic Thresholds for Foliar Disease Management in Perennial Plantings of Strawberry

Project Leaders: William Turechek and Marvin Pritts, Cornell University

Type of Grant: Monitoring, forecasting, and economic thresholds

Project Location: All of NY.

Abstract

Leaf spot, leaf blight, and leaf scorch are foliar diseases of strawberry found commonly in perennial plantings throughout North America. The effect of these diseases on strawberry production is suspected to range from reduced yields to shortened production life. A three-year study was implemented to determine to what extent these diseases impact yield and the production life of a planting, and to define when it is economically feasible to manage these diseases. The second year of the study focused on: 1) Gathering return yield, crown count, biomass, pre- and post-renovation foliar disease data in an established 'Jewel' plot in Ithaca, NY; 2) Gathering baseline yield data, crown count, biomass, pre- and post-renovation foliar disease data in new 'Kent' and 'Jewel' plots in Geneva, NY; and 3) Continuing to refine experimental procedures to look at the effects of disease under experimental conditions. The harvest from the 'Jewel' planting in Ithaca was the first in which return yield could be measured (this will occur next year for the Geneva plantings). In short, there were no differences among treatment plots with respect to yield, crown or biomass data. This is partially attributed to the difficulties in generating a disease gradient across treatment plots as well as limiting natural infection to only one pathogen. This is proving to be a much more difficult task than we anticipated. Moreover, in addition to the foliar diseases under study, powdery mildew and angular leaf spot are appearing regularly in these plantings. To circumvent future problems, we will modify our field trials to look at the cumulative effect of foliar disease, rather than focusing on any particular pathogen or set of pathogens, and we will generate 3, rather than 7, levels of foliar disease, which we believe we can accomplish by altering our fungicide regimes. We will also add a set of mechanically damaged treatment plots to simulate the effect of leaf spotting. Our greenhouse studies on scorch, spot and blight and their effect on photosynthesis are progressing. New information in regards to measuring photosynthesis has come to light, and our research plan is being adjusted accordingly. Although we were disappointed in the progress we made in generating data, we feel that our experimental procedures have been greatly improved we anticipate making great strides this year in answering the questions posed.

Background and Justification

Leaf spot (*Mycosphaerella fragariae*), leaf blight (*Phomopsis obscurans*), and leaf scorch (*Diplocarpon earlianum*) are foliar diseases of strawberry that are encountered commonly in perennial

plantings throughout North America. In a typical year, disease severity reaches its peak at or after harvest on June-bearing varieties. The extent of direct losses attributable to these diseases is not known, but high levels of disease weaken the plant and may affect winter hardiness and, quite possibly, yield in the *following* season. Furthermore, it is unclear what affect recurring annual epidemics have on the production life of a perennial planting. The average production life of a perennial matted row strawberry planting is approximately 4 years, but it is unknown whether the production life can be extended if foliar disease is well controlled. Many growers are reluctant to apply fungicides to control foliar diseases after harvest because the economic benefits of doing so are unclear. Simply, the cost of applying a fungicide with good broad-spectrum activity against foliar diseases must be compensated by an equal increase in revenue. This could be manifested either as an increase in yield in subsequent seasons, an extended life of the strawberry planting, or a combination of the two. The financial reward of extending the life of a planting is measured not only in terms of yield, but also in terms of the cost savings associated with delaying removal and re-planting of a field.

To assess the value of foliar disease management, a three-year experiment was designed to measure the effect of foliar disease on the productivity of a perennial matted-row planting. The objectives of the experiment are to: **1)** Determine the effect of leaf spot, leaf blight, and leaf scorch on the rate of photosynthesis in strawberry leaves under controlled conditions; **2)** Determine the effect of leaf spot, leaf blight, and leaf scorch on strawberry yield in perennial matted-row field plantings; and **3)** Develop an economic basis for managing foliar disease based on the relationship among disease severity, photosynthetic rate, and strawberry yield. This report summarizes the second year progress of the experiment.

Objectives

1. Determine the effect of leaf spot, leaf blight, and leaf scorch on the rate of photosynthesis in strawberry leaves under controlled conditions.

2. Determine the effect of leaf spot, leaf blight, and leaf scorch on strawberry yield in perennial matted-row field plantings.

3. Using the results obtained in objectives 1 and 2, an analysis will be performed to determine economic thresholds for the management of foliar diseases.

Procedures

OBJECTIVE 1: Plants of the varieties 'Jewel' and 'Kent' were potted in 6-inch pots and grown under greenhouse conditions. Leaves were tagged as they emerged to track leaf age (Nita et al., 2003; Zheng and Sutton, 1994). Pathogen isolates were collected from diseased leaf tissue and maintained on suitable culture medium. Pathogenicity of the isolates was maintained by periodically re-isolating the pathogens from diseased tissue following controlled inoculations. The need to follow this procedure became evident this year after several unsuccessful trials.

Individual suspensions of *P. obscurans*, *M. fragariae*, or *D. earliana* conidia were prepared by washing conidia from actively-growing cultures of the appropriate fungus into a 0.1% vol/vol Tween 20 solution and adjusting the concentration to 10^5 or 10^6 conidia/ml via a hemacytometer. Single plants were inoculated with one of the three single-pathogen suspensions, placed on a misting bench and, after a prescribed period of wetness, removed from the bench and returned to the greenhouse to allow disease to develop. We used the results of Carisse et al. (2000), Nita et al. (2003), and Zheng and Sutton (1994) as a guideline for determining suitable wetness periods. Plants inoculated with *P. obscurans* were transferred to a

30 C biotron for 3-4 days after their period of misting, prior to their being returned to a greenhouse, to provide a "heat shock" to promote disease development. By exposing plants to different leaf wetness periods, a range of disease severities were produced allowing us to evaluate the effect of disease on photosynthesis.

Photosynthesis was measured on individual leaves on each plant with a photosynthesis meter. Measurements were taken under optimal conditions (i.e., under bright sunlight, with relatively cool temperatures, between 10 am and 2 pm). Leaves were detached from the plant, scanned, and their images digitized after photosynthesis readings were taken. Leaf area and the percent of the leaf area diseased were measured from the digital images with the disease assessment program "Assess". Photosynthesis rates were averaged over leaves with identical ages on replicate plants. Data will be analyzed in a generalized linear model (GLM) with rate of photosynthesis as the response variable, disease severity and leaf age functioning as continuous predictor variables, and individual plants serving as the replication.

Addendum: During the course of this study, we have found it difficult to generate the complete range of disease severities over the full range of leaf ages for each disease. In future studies, we plan to simulate foliar disease damage by mechanical defoliation or, more specifically, using cork borers to cut holes to mimic the damage of leaf spotting (Boote, et al., 1983). Although this procedure may not fully simulate the complexity of a pathogen-plant interaction, the measured reduction in photosynthesis that will undoubtedly occur as a result of the removal of leaf tissue will produce a baseline to study the true biological interaction. This is because at least part (if not most or all) of the reduction in photosynthesis is due simply to the removal of photosynthetic area. If any additional reduction in photosynthesis occurs, it could be attributed to phenomena such the release of toxins by the invading pathogen and this can be "modeled" using the baseline as a starting point.

OBJECTIVE 2: Research plantings of the varieties 'Jewel' and 'Kent' were established on Cornell University research farms in Ithaca and Geneva in 2001. Strawberries were planted in a matted-row system on 4-ft centers. Individual plots within plantings were created by delimiting 12 ft row sections with a 3 ft buffer section on each end. To produce differential levels of foliar disease among plots, individual plots were treated with either one of three rates of Nova 40W or of three rates of Captan 50WP fungicide or were treated with no fungicide (Ellis et al., 1997). The seven treatments were arranged in a randomized complete blocks design with 4 replications. Plots were sampled once before harvest and 2 or 3 times after renovation to monitor disease development. Within each plot, fifteen leaflets (3 leaflets from 5 leaves) from 7 evenly-spaced sampling units were rated for the presence or absence of foliar disease. This sampling procedure has been used extensively in sampling for foliar diseases of strawberry in Ohio (Turechek and Madden 1999a, b and 2000).

Strawberries were harvested and weighed for each plot to provide a measurement of yield. Biomass and crown counts were recorded for each plot. Regression analysis will be used to characterize the relationship between cumulative foliar disease incidence and yield in the following year.

Addendum: During the course of our study, we have been finding it difficult to manage our plantings so that only the disease of interest develops. Additionally, other foliar pathogens, particularly powdery mildew, caused by *Sphaerotheca macularis*, and angular leaf spot, caused by the bacterial pathogen *Xanthomonas fragariae*, have become problems in our plantings. In view of these developments, we are planning to broaden the focus of our field trials to look at the cumulative effect of foliar disease, rather than on any particular pathogen or set of pathogens during the growing season. Furthermore, we will alter our fungicide regimes to generate only 3 levels of foliar disease (low, medium, and high) as we have been finding it

difficult to manage disease to produce seven, statistically distinct levels of disease. Moreover, we will simulate disease damage by mechanical defoliation (Boote, et al., 1983). Specifically, we will use a Captan 50W + Nova 40W tank mixture and apply: 1) no fungicide, should produce the highest level of disease; 2) full labeled rate on a 14-21 day schedule, should produce an intermediate level of disease; 3) full labeled rate on a 7-10 day schedule, should produce the lowest level of disease; and 4-6) full labeled rate on a strict 7 day or less schedule, with plots mechanically defoliated (as described above) in early fall to simulate disease damage (Kerkhoff et al., 1988). Three levels of mechanical damage will be simulated to correspond with disease levels in the fungicide treated plots. Except for fungicide applications, plots will be managed using standard commercial practices. Leaf area and photosynthetic rate will be compared for naturally infected and mechanically defoliated leaves.

OBJECTIVE 3: Using the results obtained in objectives 1 and 2, an analysis will be performed to determine economic thresholds for the management of foliar diseases. The analysis will be conducted using an Excel spreadsheet designed by Alison DeMarree, Regina Rieckenberg, and Marvin Pritts to evaluate the cost of strawberry production. The analysis will consider the effect of factors such as the reduction in yield relative to disease severity, the market price for strawberries, and the cost of fungicide applications. This objective will be addressed once sufficient data has been generated.

Results and Discussion

OBJECTIVE 1: In the first year of the study, we worked through several glitches in the experimental procedures, and learned how to effectively manage powdery mildew in the greenhouse in manner that would not harm or kill the pathogens that we are working with. We then began to look closely at the effect of leaf scorch on photosynthesis under controlled conditions, i.e., in a greenhouse maintained at approximately 65-70 F. We inoculated 'Honeoye' plants with the leaf scorch pathogen *Diplocarpon earliana*, placed them on a greenhouse mist bench to maintain leaf wetness, and after a prescribed period of misting, the plants were removed from the mist bench and placed on to a dry bench to allow disease development. Disease developed approximately 1 week later. By exposing plants to different leaf wetness periods, we were able to produce a range of disease severities which is necessary to effectively characterize the relationship between disease severity and photosynthesis. We then measured photosynthetic rate on individual leaves using a photosynthesis meter and determined the proportion of leaf area infected using a computer scanner and digital imaging software.

Results are shown in figure 1. It was clear that photosynthesis declined rapidly and approached zero as leaf scorch severity increased. Although interesting, it needs to be stressed that these results are preliminary. This trend may be different in the field, where environmental conditions are more variable, on different varieties, or under different experimental conditions (discussed below). Nonetheless, procedures for fungal and plant maintenance, inoculum production and plant infection are now established for this pathogen and are working very well. However, some serious questions about how we were measuring photosynthesis were brought to the forefront as we became more familiar with measuring photosynthesis.

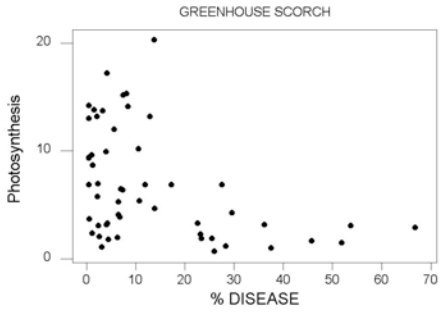

Figure 1 Effect of leaf scorch on rate of photo-synthesis on Honeoye leaves under greenhouse conditions.

After consultation with Dr. Alan Lakso and his associates, who are experts in measuring photosynthesis, it was determined that CO_2 levels for indoor measurements could not be

accurately equilibrated using the existing photosynthesis equipment available to us as it did not have an internal CO_2 source which maintains a constant CO_2 level. This is necessary under closed conditions, such as in a greenhouse where human respiration interferes with plant respiration, but not a factor under field conditions. It was also clear from discussions with Dr. Lakso that using a larger cuvette to cover a greater leaf area would more accurately measure photosynthetic rate. Dr. Lakso strongly suggested that we use a different unit with an internal CO_2 source and larger cuvette for both greenhouse and field studies for continuity and accuracy of information collected. There is one such meter currently available through Dr. Lakso's program. However, as this instrument is in very high demand during the field season for use in ongoing research projects, and windows of opportunity to measure photosynthesis are highly weather dependent (i.e., we need full sun between 10 a.m. and 2 p.m.), we were unable to begin taking field readings this season. While this was a regrettable delay, I am sure we are all in agreement that waiting, and collecting accurate data is far better than not waiting and collecting uncertain data. We have requested departmental funding for the purchase of an additional unit of this type, but given the current budget situation we are unlikely to receive this instrument any time soon. The unit belonging to the Lakso program will be available for our use during winter 2003 as they have no projects ongoing for this time period and we hope to have completed the greenhouse studies for *D. earliana* and perhaps the other two fungi (see below) before field season 2003 begins in late April.

Initial experiments with the leaf spot pathogen, *Mycosphaerella fragariae*, were very successful. However, we learned that the pathogen looses its pathogenicity after 2 to 3 successive transfers in culture, necessitating re-isolation from infected tissue each time prior to carrying out the next experiment. Procedures are now in place to carry out photosynthesis experiments with this pathogen, but they will proceed at a slightly slower rate than those of *D. earliana,* as the pathogen will require re-isolation at frequent intervals. Experiments with *Phomopsis obscurans* brought little results initially, and symptoms developing under greenhouse conditions took a month or more to be expressed. After several months of experimentation, we were able to determine that the temperature the plants were kept at after we inoculated them and/or "heat-shocking" the plants was critical to induce symptom expression. We were able to secure the use of 2 departmental biotron units that can provide the higher temperatures needed for more rapid symptom development. Further work with *P. obscurans* will be done in these units rather than under greenhouse conditions as with the other 2 pathogens. Plants will be moved back to the greenhouse after symptoms develop to take photosynthesis readings.

Initial inoculation experiments have been undertaken with *Gnomonia comari*, the strawberry leaf blotch fungus, which has been frequently isolated from what we thought were leaf blight-infected leaves. We reviewed the literature for existing information on the pathogen and its biology, which provided initial insights for experimental procedures. As yet we have been unsuccessful in achieving symptom expression with this pathogen. We will continue to work out these procedures during the coming winter.

OBJECTIVE 2: Research continued for the second year in the 3-year-old 'Jewel' planting in Ithaca, NY. Additional research plantings of 'Jewel' and 'Kent' strawberries were established in spring 2001 located at NYSAES Darrow Farm in Geneva, NY. Individual plots within the planting were created by subdividing the row into six 12 ft sections, with 3 ft buffer sections between each. To get differential levels of disease across the plots, the fungicides Nova or Captan were applied at various reduced rates. This year, in addition to harvesting berries to get a baseline estimate of yield per plot, we collected biomass and crown counts at renovation to more fully look at the effect of disease severity on the planting in succeeding years. Collected biomass (i.e., mowed-off leaf tissue) for all plots was bagged and dried for 1 month prior to recording dry weight. Disease incidence was rated in each plot just prior to renovation in mid summer, and again in late fall after establishment of the new crowns. Return yield, crown

counts, and biomass were collected for the 'Jewel' planting in Ithaca. Results for Ithaca and Geneva plots are displayed in tables below. Numbers presented are average values for six replications. Values followed by a common letter are statistically equivalent.

Jewel Planting (Ithaca): A summary of return yield data, crown count and biomass is presented in the table to the right. No significant differences were observed between treatments or the control for yield, crown count or biomass for this harvest season. Further, comparisons between 2001 and 2002 yield for all treatments showed no significant differences at this point (analysis results not shown). These results are discussed further in the foliar disease section below.

	2001	2002		
Treatment	Total berry weight (kg)	Total berry weight (kg)	Biomass (kg)	Crown count
Captan 0.16 lb/A	8.00 a	7.71 a	0.56 a	58 a
Captan 1.0 lb/A	8.71 a	7.80 a	0.51 a	66 a
Captan 1.5 lb/A	8.30 a	8.34 a	0.54 a	61 a
Nova 0.25 oz/A	9.39 a	8.34 a	0.60 a	62 a
Nova 1.0 oz/A	8.95 a	8.44 a	0.59 a	61 a
Nova 2.5 oz/A	8.32 a	8.37 a	0.61 a	64 a
Control	9.33 a	8.32 a	0.60 a	53 a

This 3-year-old 'Jewel' planting was fairly vigorous coming into harvest and yield in control plots was comparable with 2001. Regrettably, we noted a large proportion of the fruit harvested was infected with leather rot (*Phytophthora cactorum*). After renovation many crowns appeared weak or dead. In some instances, 12 ft plot sections contained as few as 12 viable crowns after renovation. Regrowth was slow for the remaining crowns. In all probability many of the plants were also infected with *P. cactorum* early in the season. The ensuing drought further weakened infected crowns resulting in large areas of dead plants in each row. Because these factors may confound future results, we are considering discontinuing the work in this particular planting.

Table 1. Two-year summary of foliar disease intensity pre- and post-renovation for the 'Jewel' planting in Ithaca.

	Post Renovation 2001			Pre Renovation 2002			Post Renovation 2002		
Treatment	Leaf Blight	Leaf Spot	Leaf Scorch	Leaf Blight	Leaf Spot	Leaf Scorch	Leaf Blight	Leaf Spot	Leaf Scorch
Captan 0.165 lb/A	42.7 ab	0.0 a	0.0	83.5 a	0.0 a	0.0 a	48.6 a	1.0 a	0.6 a
Captan 1.0 lb/A	49.5 ab	0.0 a	0.0	71.8 ab	0.0 a	0.4 a	45.6 a	0.3 a	0.2 a
Captan 1.5 lb/A	46.0 ab	0.0 a	0.0	63.3 b	0.0 a	0.2 a	47.5 a	0.2 a	1.0 a
Nova 0.25 oz/A	44.9 ab	0.2 a	0.0	73.8 ab	0.3 a	0.4 a	38.1 a	0.8 a	0.0 a
Nova 1.0 oz/A	32.2 b	0.2 a	0.0	76.5 ab	0.0 a	0.4 a	45.9 a	0.8 a	0.2 a
Nova 2.5 oz/A	35.3 b	0.9 a	0.0	71.8 ab	0.0 a	0.8 a	37.0 a	0.5 a	0.0 a
Control	54.9 a	0.0 a	0.0	79.2 ab	0.0 a	0.0 a	45.4 a	0.0 a	0.2 a

Fungicides were applied at mid-bloom on June 12 2002. Pre- and post-renovation foliar disease data were taken on July 10 and October 8, 2002, respectively. Disease data for all 3 fungal pathogens for both 2001 and 2002 are shown in Table 1 above. Some separation between treatments was found for leaf blight infected leaves in fall of 2001 and spring of 2002, but not for fall of 2002. One application at mid-bloom was not sufficient to give differential levels of disease in this instance. While statistically different levels of disease were achieved for the two highest Nova treated plots in 2001, this apparently did not have a strong affect yield in 2002.

Kent Planting (Geneva): As projected for the baseline year, no significant differences were seen between treatments and the control for yield, crown counts or biomass (right). However, a large number of berries at harvest were infected with anthracnose, caused by the fungus *Colletotrichum acutatum*. The disease seemed to be distributed throughout the planting and appeared to have little effect on yield across treatments (i.e., number of berries), crown counts or biomass for harvest 2002. It is not clear what effect, if any, anthracnose may have on yield in year 2 of the project in these trials. Foliar infections by *C. acutatum* most commonly occur in southern growing regions under much warmer growing conditions and were not found in this planting either pre or post-renovation. We will continue to monitor for the foliar phase of this disease in next year's crop.

Treatment	Total berry weight (kg)	Biomass (kg)	Crown count
Captan 0.165 lb/A	5.93 a	0.55 a	70 a
Captan 1.0 lb/A	5.88 a	0.52 a	66 a
Captan 1.5 lb/A	5.39 ab	0.53 a	76 a
Nova 0.25 oz/A	4.35 b	0.54 a	71 a
Nova 1.0 oz/A	5.46 ab	0.56 a	71 a
Nova 2.5 oz/A	4.77 ab	0.50 a	66 a
Control	5.11 ab	0.48 a	60 a

Table 2. Summary of foliar disease intensity pre- and post-renovation in the 'Kent' planting in Geneva.

	Pre Renovation 2002					Post Renovation 2002			
Treatment	Leaf Blight	Leaf Spot	Leaf Scorch	ALS*	Total	Leaf Blight	Leaf Spot	Leaf Scorch	Total
Captan 0.165 lb/A	4.9 a	0.5 a	4.6 a	10.5 a	27.9 a	17.4 a	0.8 a	14.8 a	33.0 a
Captan 1.0 lb/A	2.7 a	0.9 a	7.8 a	11.1 a	26.9 a	11.1 a	0.3 a	0.3 a	25.5 a
Captan 1.5 lb/A	5.0 a	1.0 a	5.2 a	4.0 a	23.8 a	11.1 a	0.8 a	9.5 ab	20.9 a
Nova 0.25 oz/A	1.3 a	0.0 a	4.1 a	4.7 a	14.7 a	10.5 a	0.9 a	13.0 ab	24.6 a
Nova 1.0 oz/A	7.3 a	0.0 a	0.9 a	15.1 a	29.6 a	10.1 a	2.5 a	9.8 ab	22.5 a
Nova 2.5 oz/A	2.4 a	1.1 a	4.3 a	5.1 a	19.5 a	14.3 a	0.9 a	8.6 ab	23.8 a
Control	1.3 a	0.3 a	1.7 a	11.7 a	20.3 a	14.0 a	0.5 a	7.9 ab	22.4 a

* Angular leaf spot

Pre harvest fungicide applications were made at early bloom and 7 days later (23 and 30 May). Post harvest applications were made August 23, September 26, and October 4, respectively. Disease was rated July 12 and October 15 and is summarized in Table 2. Leaf scorch and leaf blight were the most common diseases present however, it is leaf spot that we expect to see develop in this planting. Some leaf spot was found and we are hoping that what disease did develop this year will be enough to initiate a greater epidemic next year. Angular leaf spot was prevalent pre-renovation but was not detected after renovation. There were no significant differences among treatments for any of the foliar diseases rated.

Xanthomonas fragariae, the bacterium causing angular leaf spot, was the most common foliar pathogen encountered. The 'Kent' and, to a lesser degree, the 'Jewel' planting were infected with angular leaf spot during July and August of the planting year (2001), with 60-70% of the plants sampled showing infection on 24 July when the disease was first noted and 95% of the plants surveyed showing infection by the 2 August sample date. As the planting site had been fallow ground for the past 10 years and no other infected plantings were in the immediate vicinity to serve as inoculum sources, we are led to believe infected nursery stock was the source of this infection. Overhead irrigation was immediately ceased after detection of angular leaf spot and three applications of Kocide 2000 were applied at 7-10 day intervals to prevent further disease spread. The literature reports this bacterium usually does not persist past the planting year in most regions. Contrarily, we had reoccurrence of the disease in the 2002 growing season. Although the percentage of plants showing infection was much less than the previous year it still accounted for 58% of the total leaflet infections.

Jewel planting (Geneva): Some anthracnose was present in this planting as well, but berry infections were less numerous than in the 'Kent' planting. Yield and crown counts did not differ significantly among treatments in the first harvest year of this new planting (right). In contrast, two overlapping groups could be distinguished with respect to biomass. However, the groupings did not appear to be related to rate or type of product applied or crown count, as might be expected

Treatment	Total berry weight (kg)	Biomass (kg)	Crown count
Captan 0.165 lb/A	7.27 a	0.50 b	73 a
Captan 1.0 lb/A	7.55 a	0.68 a	59 a
Captan 1.5 lb/A	6.79 a	0.56 ab	69 a
Nova 0.25 oz/A	7.51 a	0.56 ab	65 a
Nova 1.0 oz/A	7.66 a	0.57 ab	67 a
Nova 2.5 oz/A	7.79 a	0.50 b	65 a
Control	7.04 a	0.50 b	66 a

Table 3. Summary of foliar disease intensity pre- and post-renovation in the 'Jewel' planting in Geneva.

	Pre Renovation 2002				Post Renovation 2002			
Treatment	Leaf Blight	Leaf Spot	Leaf Scorch	Total Disease	Leaf Blight	Leaf Spot	Leaf Scorch	Total
Captan 0.165 lb/A	1.90 a	1.59 a	60.95 a	65.40 a	25.56 a	0.95 a	0.00 a	26.83 ab
Captan 1.0 lb/A	4.92 a	0.16 a	58.73 a	69.05 a	39.05 a	0.16 a	0.00 a	39.21 ab
Captan 1.5 lb/A	10.32 a	0.32 a	57.46 a	71.90 a	42.06 a	0.00 a	0.00 a	42.06 a
Nova 0.25 oz/A	7.14 a	0.48 a	57.14 a	75.08 a	18.89 a	0.63 a	0.00 a	19.84 b
Nova 1.0 oz/A	11.59 a	0.48 a	59.21 a	62.06 a	29.84 a	1.11 a	0.32 a	32.70 ab
Nova 2.5 oz/A	1.43 a	1.59 a	55.87 a	60.00 a	30.79 a	0.48 a	0.00 a	31.27 ab
Control	4.60 a	0.63 a	51.11 a	72.38 a	35.87 a	0.48 a	0.00 a	36.67 ab

Fungicides were applied and data taken on the same dates as noted above for the 'Kent' trial pre- and post-renovation. Results for pre-renovation foliar disease are recorded in Table 3. Leaf scorch was the most prevalent foliar pathogen found pre- renovation, followed by blight. No significant differences in foliar disease from individual pathogens or cumulative foliar disease were apparent. Leaf blight was more prevalent post-renovation as expected. Leaf scorch was less prevalent post-renovation than pre-renovation.

In summary, the timing, frequency, and/or rates of fungicide applications must be adjusted to give differential levels of disease pre- and post-renovation. This is based on our inability to achieve adequate separation of disease intensity among plots in the 'Jewel' planting in Ithaca. As this is the oldest of the three plantings, we are fortunate that we can make adjustments in our younger plantings in Geneva based on our mistakes in the Ithaca planting. The adjustments are interesting and are discussed in the addenda above.

OBJECTIVE 3: This objective will be addressed in the future once sufficient data has been collected from objectives 1 and 2.

References

1. Boote, K.J., Jones, J.W., Mishoe, J.W., and Berger, R.D. 1983. Coupling pests to crop growth simulators to predict yield reductions. Phytopathology 73:1581-1587.
2. Carisse, O., and Peyrachon, B. 1999. Influence of temperature, cultivar, and time on sporulation of *Mycosphaerella fragariae* on detached strawberry leaves. Canadian Journal of Plant Pathology 21:276-283.
3. Carisse, O., Bourgeois, G., and Duthie, J.A. 2000. Influence of temperature and leaf wetness duration on infection of strawberry leaves by *Mycosphaerella fragariae*. Phytopathology 90:1120-1125.
4. Delhomez, N., Carisse, O., Lareau, M., and Khanizadeh, S. 1995. Susceptibility of seventeen selected strawberry cultivars and six advanced selections to leaf spot caused by *Mycosphaerella fragariae*. Hort Science 30:592-593.
5. Ellis, M.A. 1995. Integrated Pest Management (IPM). Disease management guidelines for strawberries in Ohio. Ohio State University. Plant Pathology Dept. Series: 93.
6. Ellis, M.A. 1998. Strawberry leaf spot diseases. Ohio State University Extension Fact Sheet. HYG-3015-95.
7. Ellis, M.A., Turechek, W.W., and Madden, L.V. 1997. Evaluation of fungicides for control of strawberry leaf blight. Strawberry IPM Update. Iowa State University. Vol. 4, No. 3.
8. Eshenaur, B.C., and Milholland, R.D. 1989. Factors influencing the growth of *Phomopsis obscurans* and disease development on strawberry leaf and runner tissue. Plant Disease 73:814-819.
9. Fall, J. 1951. Studies on the fungus parasites of strawberry leaves in Ontario. Canadian Journal of Botany 29(4) 299-315.
10. Howard, C.M. and Albregts, E.E. 1973. A strawberry fruit rot caused by *Dendrophoma obscurans*. Phytopathology 63:419-421.
11. Kerkhoff, K.L., Williams, J.M., and Barden, J.A. 1988. Effects of defoliation on growth and yield of 'Redchief' strawberries. Advances in Strawberry Production 7:26-28.
12. Maas, J. L., ed. 1984. Compendium of Strawberry Diseases. American Phytopathological Society, St. Paul, MN. 138 pp.
13. Nemec, S. 1972. Temperature effects on *Mycosphaerella fragariae* and strawberry leaf spot development. Plant Dis. Rep. 53:94-97.
14. Nita, M., Ellis, M.A., and Madden, L.V. 2003. Effects of temperature, wetness duration, and leaflet age on infection of strawberry foliage by *Phomopsis obscurans*. Plant Disease (*submitted*).
15. Sproat, B.B., Darrow, G.M. and Beaumont, J.H. 1935. Relation of leaf area to berry production in strawberry. Proc. Amer. Soc. Hort. Sci. 33:389-392.
16. Turechek, W.W., and Madden, L.V. 1999a. Spatial pattern analysis of strawberry leaf blight in perennial production systems. Phytopathology 89:421-433
17. Turechek, W.W., and Madden, L.V. 1999b. Spatial pattern analysis and sequential sampling for the incidence of leaf spot on strawberry in Ohio. Plant Dis. 83:992-1000.
18. Turechek, W.W., and Madden, L.V. 2000. Analysis of the association between the incidence of two spatially aggregated foliar diseases of strawberry. Phytopathology 90:157-170.
19. Xue, A.G., Sutton, J.C., Dale, A., and Sullivan, J.A. 1996. Differences in virulence of *D. earlianum* isolates on selected strawberry cultivars. Phytoprotection 77:113-118.
20. Zheng, J., and Sutton, J.C. 1994. Inoculum concentration, leaf age, wetness duration, and temperature in relation to infection of strawberry leaves.